

# Endovascular intervention for basilar artery occlusion in the elderly

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## Abstract

**Background:** To date, few data have been reported on clinical outcomes following interventions in elderly populations with acute basilar artery occlusion. Using data from the Endovascular Treatment for Acute Basilar Artery Occlusion Study (BASILAR), we evaluated the efficacy and safety of intervention and determined predictors of outcomes among elderly patients in China.

**Methods:** Patients from January 2014 to May 2019 were dichotomized into elderly (75 years or older) and nonelderly patients (under 75 years). Pearson's Chi-square test and multivariate logistic regression were performed to assess 90-day favorable functional outcome (defined as a modified Rankin scale score of 0–3), mortality and symptomatic intracranial hemorrhage between intervention and conservative cohorts in elderly patients.

**Results:** Among the 829 patients in the BASILAR, 182 patients aged 75 years or older were analyzed. These patients were divided into intervention (127 patients) and conservative (55 patients) cohorts. Compared with the conservative cohort, the intervention cohort presented more frequently with a favorable functional outcome (28.3% versus 12.7%;  $p=0.023$ ) and with a decreased mortality (54.3% versus 76.4%;  $p=0.005$ ). There was no difference in symptomatic intracranial hemorrhage (4.7% versus 0,  $p=0.235$ ). Multivariate analysis indicated that intervention was associated with favorable functional outcome (adjusted odds ratio, 0.262; 95% confidence interval, 0.088–0.778,  $p=0.016$ ) and lower mortality (adjusted odds ratio, 0.257; 95% confidence interval, 0.109–0.606,  $p=0.002$ ). In the intervention cohort, initial National Institutes of Health Stroke Scale (NIHSS) score and occlusion site were associated with functional outcome, and initial NIHSS score and recanalization were associated with mortality.

**Conclusions:** Although the overall outcome following intervention was worse with age, intervention was more effective and safer than conservative treatment for elderly Chinese patients with basilar artery occlusion. Predictors of desirable outcome in elderly patients undergoing intervention included lower initial NIHSS score, occlusion site and successful recanalization.

Clinical Trial Registration-URL: <http://www.chictr.org>. Unique identifier: ChiCTR-1800014759

**Keywords:** basilar artery occlusion, elderly, endovascular treatment, intervention, stroke

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## Introduction

To date, patients with basilar artery occlusion (BAO) would have had more severe outcomes if left untreated. This devastating disease presents with high mortality, causing up to 68% of victims to have

poor outcomes.<sup>1</sup> Previous studies have shown that acute BAO was usually associated with a high rate of morbidity and mortality without active treatment.<sup>2</sup> The benefit of intervention has yet to be demonstrated, as recent independent randomized

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controlled trials focusing on management of acute BAO have failed to statistically demonstrate the superiority of intervention.<sup>3,4</sup> However, intervention treatment has been increasingly applied as a common strategy for patients with BAO in daily clinical practice. In the Basilar Artery International Cooperation Study (BASICS) from 2009, as many as 329 (55.6%) of the 592 patients were treated with intra-arterial therapy.<sup>1</sup> In the nationwide, multicenter, prospective registry study, termed BASILAR (the Endovascular Treatment for Acute Basilar Artery Occlusion Study) from 2020, this number was 647 (78%).<sup>5</sup> These results demonstrated that for patients with acute BAO, the devastating outcome limited the acceptance of conservative, and treating physicians tended to apply more aggressive endovascular interventions in many cases in expectation of lowering disability and mortality rates. Although interventional approaches have been used to treat BAO with a tendency toward a benefit over the last few years, limited data on the efficacy and safety of intervention were available in the elderly population.

Patient demographics were characterized by a marked aging due to the increase in life expectancy and improvements in medical care. The ever-growing elderly population was much more vulnerable to acute cerebral ischemia than the younger population, leading to a higher incidence of cerebral ischemia in this group.<sup>6</sup> In addition, this patient population became disabled after stroke more often than the younger population.<sup>7</sup> Elderly patients will soon represent the majority of BAO victims, resulting in a substantial impact on health services in the near future.<sup>8</sup> While interventional therapy for elderly patients with acute BAO was currently not considered the standard of care, it was offered at many comprehensive stroke centers or tertiary hospitals in China. It was believed that there was clinical equipoise and that further study was warranted.

Here, we analyzed data from the BASILAR to assess the efficacy and safety of intervention for patients  $\geq 75$  years of age and to determine the factors affecting the clinical outcome.

## Methods

### Patients selection

Patients from the BASILAR were included. The investigator-initiated multicenter perspective

BASILAR registry aimed to assess the efficacy and safety of intervention for patients with acute BAO. Consecutive patients from 47 senior stroke sites across 15 provinces in China were included from January 2014 to May 2019. Patients at each stroke site were required to be included to avoid selection bias. Eligible patients were aged 18 years or older, presented with acute, symptomatic angiographically confirmed BAO within 24 h of estimated occlusion time, and underwent intravenous thrombolysis if in the therapeutic time window. The choice of treatment was at the discretion of the treating physician at the investigation site.

Ethical approval for the study was obtained by the local institutional review board of each site. Written informed consent was obtained from the patients or, if unable to provide consent, their legal surrogates, as required by the authorities' guidelines. BASILAR was registered with the Chinese Clinical Trial Registry (<http://www.chictr.org.cn>, ChiCTR1800014759).

### Parameter definitions

The BASILAR cohort was dichotomized into elderly and nonelderly groups. Elderly patients were defined as those 75 years or older and nonelderly patients were defined as those younger than 75 years. Patients in both age groups were divided into intervention cohorts (standard medication plus mechanical thrombectomy, thromboaspiration, balloon angioplasty, stenting, or a combination of these approaches) and conservative cohorts (standard medication alone, including antiplatelet or anticoagulation therapy, intravenous thrombolysis, or a combination of these therapies). The specific method of treatment was left to the discretion of the local interventionalist. The presumed causative mechanism of stroke was assessed based on the Trial of ORG10172 in Acute Stroke Treatment (TOAST) classification.<sup>9</sup>

The ischemic changes were quantified by the posterior circulation Alberta Stroke Program Early Computed Tomography Score (pc-ASPECTS, range 0–10, with scores  $\geq 8$  correlating with favorable outcome).<sup>10</sup> The collateral circulation status was assessed by the posterior circulation collateral score (PC-CS) based on the presence of potential collateral pathways on computed tomography angiography.<sup>11</sup> The technical outcome of interventional treatment was assessed by

the modified Thrombolysis in Cerebral Infarction score.<sup>12</sup> Successful vessel recanalization was defined as a modified Thrombolysis in Cerebral Infarction score of 2b or 3 at the end of the procedure as confirmed by the imaging core laboratory according to individual angiographic data.

The efficacy outcome was the proportion of patients with favorable functional outcome defined by the follow-up modified Rankin scale (mRS) score at 90 days. The mRS is a seven-level categorical scale that measures functional outcomes with scores ranging from 0 (no symptoms) to 6 (death). Given the documented dismal natural history of BAO,<sup>13</sup> favorable functional outcome was defined as an mRS of 3 or less, and poor functional outcome defined as an mRS of 4 or more. We also investigated whether the results changed if favorable functional outcome was defined as an mRS of 0–2 and 0–1.

The safety outcomes were the incidence of death within 90 days after symptoms onset and the symptomatic intracranial hemorrhage as diagnosed within 48 h after intervention treatment. Symptomatic intracranial hemorrhage, defined according to the Heidelberg Bleeding Classification, was detected by brain imaging associated with any of the following items: an increase by  $\geq 4$  points of the total National Institutes of Health Stroke Scale (NIHSS), an increase by  $\geq 2$  points of a NIHSS subcategory as a relevant change in neurological status, the absence of alternative explanation for deterioration or leading to intubation/hemicraniectomy/external ventricular draining placement or other major medical/surgical intervention.<sup>14</sup>

### Statistical analysis

Data were presented as medians and interquartile ranges (IQRs) unless indicated otherwise. Univariate analysis was first performed to compare the baseline demographic and clinical characteristics of elderly patients between the intervention and conservative cohorts, using the Mann–Whitney *U* test for numerical variables and Pearson's Chi-square test or Fisher's exact test for categorical variables as appropriate. The *t* test was used for variables that were normally distributed (Kolmogorov–Smirnov test:  $p > 0.05$ ), such as the initial systolic and diastolic blood pressure for the elderly patients. Binary outcomes were analyzed with logistic regression to estimate the treatment effect and to determine predictors of functional

outcome and mortality. The adjusted and unadjusted odds ratios (ORs) were reported with 95% confidence intervals (CIs) to indicate statistical precision. To generate the benefit curves related to the treatment modalities, outcome-specific predicted probabilities for continuous age values were computed by setting other variables in the model to their mean values.

In this study, the missing values of key variables were excluded from analysis, and thus there was no need for imputation. The significance level was set at  $p < 0.05$  and all *p*-values were two-sided. Statistical analysis was performed using SPSS version 23.0 (IBM Corp., Armonk, NY, USA) and STATA version 15.2 (Stata Corp LLC, TX, USA). Percentage bar plots were drawn in Excel 2020 software (Microsoft). Distribution surfaces representing changes in predicted outcome probabilities were generated using SigmaPlot 12.5, with models assessed using the  $R^2$  correlation metric.

## Results

### Baseline characteristics of the BASILAR full cohort

There were 829 acute BAO patients from 47 stroke sites in China enrolled in the BASILAR registry.<sup>5</sup> Of these, 647 were  $< 75$  years and 182 were  $\geq 75$  years of age. The median (IQR) age of the full cohort was 65 (57–74) years.

### Outcome with intervention versus conservative in the elderly

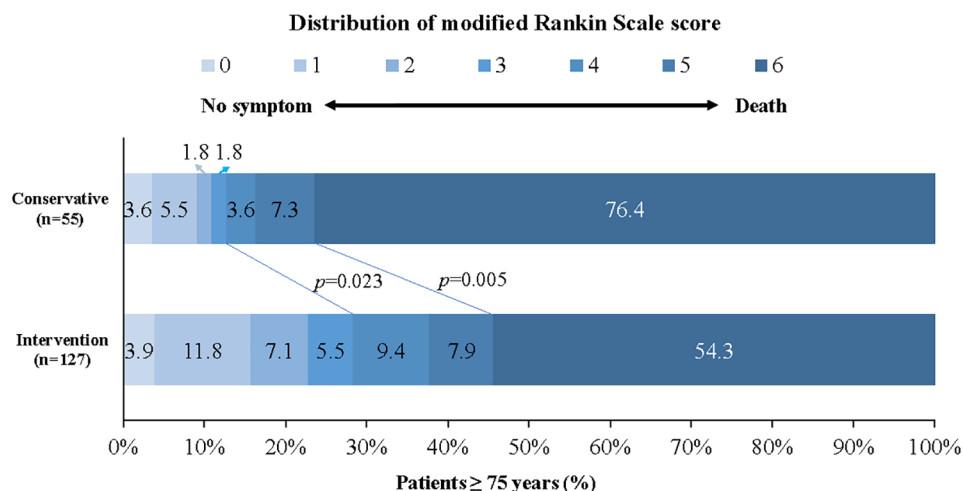
There were 182 patients aged 75 years or older [58.8% male; median (IQR) age, 78 (76–81) years; age range, 75–91 years]. When dichotomizing the elderly patients, 127 of 182 (69.8%) were intervention-treated cohort [median (IQR) age, 78 (76–81) years] and 55 of 182 (30.2%) were conservative-treated cohort [median (IQR) age, 79 (77–81) years]. The baseline characteristics of the elderly patients and univariate analysis are presented in Table 1.

In the univariate analysis, compared with the conservative cohort, the intervention cohort presented a higher rate of favorable functional outcome (28.3% versus 12.7%;  $p = 0.023$ ) and a decreased mortality (54.3% versus 76.4%;  $p = 0.005$ ) (Figure 1). No difference was observed for functional outcome when it

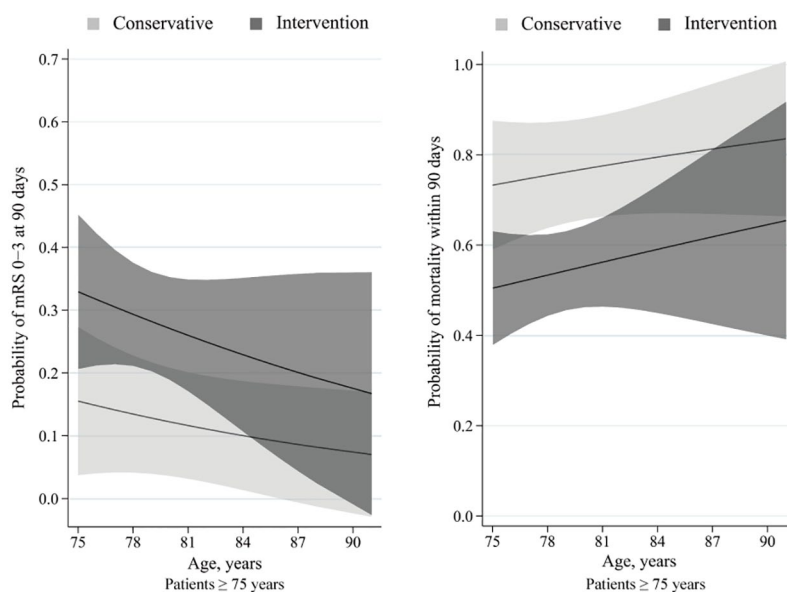
**Table 1.** Baseline characteristics of patients  $\geq 75$  years with acute BAO.

Characteristics	All patients	Intervention	Conservative	<i>p</i> -value
	( <i>n</i> = 182)	( <i>n</i> = 127)	( <i>n</i> = 55)	
Age, median (IQR), years	78 (76–81)	78 (76–81)	79 (77–81)	0.363
Sex, male, <i>n</i> (%)	107 (58.8)	79 (62.2)	28 (50.9)	0.155
NIHSS baseline score, median (IQR)	28 (16–34)	28 (17–34)	22 (14–31)	0.025
pc-ASPECTS baseline, median (IQR) <sup>a</sup>	8 (6–9)	8 (7–9)	7 (6–9)	0.062
PC-CS score, median (IQR)	4 (3–6)	4 (4–6)	4 (2–6)	0.196
SBP, mean (SD), mm Hg	156 (27.4)	152 (26.0)	164 (28.9)	0.008
DBP, mean (SD), mm Hg	85 (15.8)	84 (16.0)	89 (15.1)	0.062
Medical history, <i>n</i> (%)				
Hypertension	142 (78.0)	102 (80.3)	40 (72.7)	0.256
Hyperlipidemia	34 (18.7)	21 (16.5)	13 (23.6)	0.259
Diabetes mellitus	36 (19.8)	24 (18.9)	12 (21.8)	0.650
Atrial fibrillation	68 (37.4)	56 (44.1)	12 (21.8)	0.004
Cerebral infarction	48 (26.4)	32 (25.2)	16 (29.1)	0.584
Intracerebral hemorrhage	6 (3.3)	3 (2.4)	3 (5.5)	0.283
Coronary artery disease	39 (21.4)	30 (23.6)	9 (16.4)	0.273
Heart failure	14 (7.7)	9 (7.1)	5 (9.1)	0.870
Chronic bronchitis	3 (1.6)	2 (1.6)	1 (1.8)	1.000
Current or ex-smoker	34 (18.7)	28 (22.0)	6 (10.9)	0.077
Cause of stroke, <i>n</i> (%)				0.001
Large artery atherosclerosis	86 (47.3)	56 (44.1)	30 (54.5)	
Cardioembolism	80 (44.0)	65 (51.2)	15 (27.3)	
Other causes	16 (8.8)	6 (4.7)	10 (18.2)	
Occlusion sites, <i>n</i> (%)				0.032
Distal basilar artery	84 (46.2)	65 (51.2)	19 (34.5)	
Middle basilar artery	61 (33.5)	34 (26.8)	27 (49.1)	
Proximal basilar artery	18 (9.9)	13 (10.2)	5 (9.1)	
Vertebral artery-V4	19 (10.4)	15 (11.8)	4 (7.3)	
Intravenous thrombolysis, <i>n</i> (%)	35 (19.2)	22 (17.3)	13 (23.6)	0.321
OTT, median (IQR), min	239 (121–362)	261 (151–365)	208 (89–329)	0.046

<sup>a</sup>Data were missing for one patient in the conservative cohort.  
BAO, basilar artery occlusion; DBP, diastolic blood pressure; IQR, interquartile range; NIHSS, National Institutes of Health Stroke Scale; OTT, onset-treatment time; pc-ASPECTS, posterior circulation Alberta Stroke Program Early Computed Tomography Score; PC-CS score, posterior circulation collateral system score; SBP, systolic blood pressure.



**Figure 1.** Distribution of modified Rankin scale score at 90 days in patients  $\geq 75$  years. Shown was the distribution of the modified Rankin scale scores at 90 days in patients aged 75 years and older. The distribution showed that compared with conservative treatment, intervention treatment was associated with a higher rate of favorable functional outcome and lower mortality among patients  $\geq 75$  years.



**Figure 2.** Predicted probability of clinical outcome by age in patients  $\geq 75$  years. Curves showed that among patients aged 75 years or older, the intervention cohort presented with a higher predicted probability of favorable functional outcome and a lower predicted probability of mortality than the conservative cohort. The solid line indicates its predicted probability of outcomes and grey shading indicates its 95% confidence interval.

was defined by different mRS scores (mRS 0–2: 22.8% *versus* 10.9%,  $p=0.061$ ; mRS 0–1: 15.7% *versus* 9.1%,  $p=0.231$ ).

The probability of favorable functional outcome decreased with age, and the probability of mortality increased with age. The between-line difference

in the probability of both outcomes was approximately 20% between the intervention and conservative cohorts (Figure 2). No difference was detected in the proportion of symptomatic intracranial hemorrhage (4.7% *versus* 0,  $p=0.235$ ) between the intervention and conservative cohorts, respectively.

**Table 2.** Multivariate analysis: predictors of outcome in patients  $\geq 75$  years.

Variables	Unadjusted OR (95% CI)	p-value	Adjusted OR <sup>a</sup> (95% CI)	p-value
Functional outcome				
Initial NIHSS score	1.067 (1.03–1.106)	<0.001	1.106 (1.055–1.160)	<0.001
PC-CS score	0.787 (0.649–0.954)	0.015	0.908 (0.709–1.163)	0.446
Occlusion sites				
Distal basilar artery <sup>b</sup>		0.039		0.005
Middle basilar artery	2.889 (1.246–6.695)	0.013	4.997 (1.792–13.931)	0.002
Proximal basilar artery	1.750 (0.527–5.812)	0.361	2.290 (0.582–9.004)	0.236
Vertebral artery-V4	4.250 (0.917–19.702)	0.064	8.020 (1.498–42.924)	0.015
Intervention	0.369 (0.153–0.890)	0.027	0.262 (0.088–0.778)	0.016
Mortality				
Initial NIHSS score	1.063 (1.030–1.098)	<0.001	1.082 (1.040–1.126)	<0.001
PC-CS score	0.742 (0.622–0.885)	0.001	0.817 (0.663–1.008)	0.059
Intervention	0.368 (0.180–0.751)	0.006	0.257 (0.109–0.606)	0.002

<sup>a</sup>Adjusted estimates of effect were calculated using multiple regression taking the following variables into account: age, initial NIHSS, PC-CS score, occlusion site, onset to treatment time, intravenous thrombolysis and type of treatment.

<sup>b</sup>Distal basilar artery was taken as reference.

CI, confidence interval; NIHSS, National Institutes of Health Stroke Scale; OR, odds ratio; PC-CS score, posterior circulation collateral system score.

Adjusting for age, initial NIHSS, PC-CS, occlusion site, onset to treatment time, intravenous thrombolysis and type of treatment, the multivariate analysis confirmed that initial NIHSS (OR, 1.106; 95% CI, 1.055–1.160;  $p < 0.001$ ), occlusion site and intervention treatment (OR, 0.262; 95% CI, 0.088–0.788;  $p = 0.016$ ) were associated with functional outcome, and that initial NIHSS (OR, 1.082; 95% CI, 1.040–1.126;  $p < 0.001$ ) and intervention treatment (OR, 0.257; 95% CI, 0.109–0.606;  $p = 0.002$ ) were associated with mortality (Table 2).

#### Predictors of outcome with intervention in the elderly

To identify the predictors of outcome following intervention, the 127 elderly patients with intervention were dichotomized by functional outcome (favorable *versus* poor) and mortality (alive *versus* deceased) to determine the variables to be adjusted. The adjusted variables were calculated using multiple logistics regressions, taking the

following into account: age, initial NIHSS, initial PC-CS, occlusion site, puncture to recanalization time and recanalization. Analysis demonstrated initial NIHSS (OR, 1.142; 95% CI, 1.070–1.219;  $p < 0.001$ ) and occlusion site as predictors of functional outcome. And initial NIHSS (OR, 1.121; 95% CI, 1.059–1.186;  $p < 0.001$ ) and recanalization (OR, 0.230; 95% CI, 0.064–0.826;  $p = 0.025$ ) were predictors of mortality (Table 3). The predicted probability of outcome with age and initial NIHSS were shown *via* distribution surfaces (Figure I in the Supplementary Material).

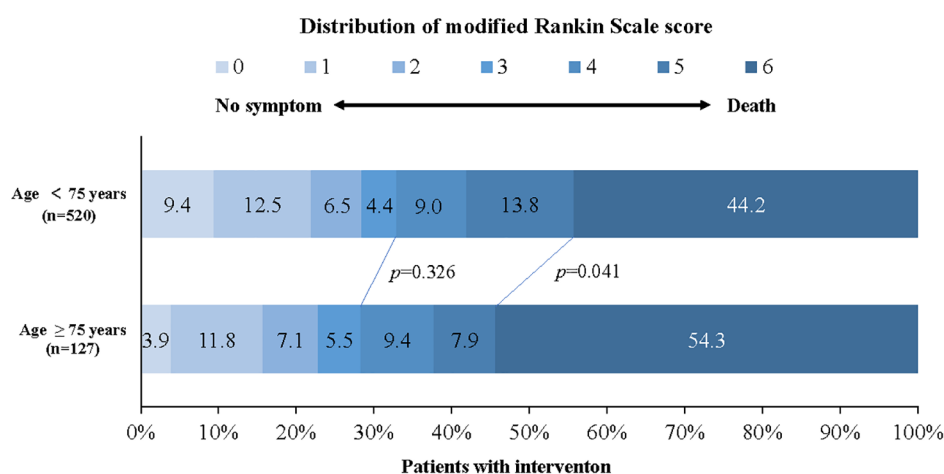
#### Outcome of intervention in the elderly versus nonelderly patients

Among all patients treated with intervention in the BASILAR, 520 of 647 (80.4%) were nonelderly (median, 62; IQR, 54–67) and 127 of 647 (19.6%) were elderly patients (median, 78; IQR, 76–81). The characteristics of patients with intervention and univariate analysis are presented in Table I in the Supplementary Material.

**Table 3.** Multivariate analysis: predictors of outcome following intervention in patients  $\geq 75$  years.

Variables	Unadjusted OR (95% CI)	<i>p</i> -value	Adjusted OR (95% CI)	<i>p</i> -value
Functional outcome				
Age	1.017 (0.907–1.140)	0.779	0.933 (0.808–1.079)	0.351
Initial NIHSS score	1.080 (1.034, 1.129)	0.001	1.142 (1.070–1.219)	<0.001
Occlusion sites				
Distal basilar artery <sup>a</sup>		0.034		0.014
Middle basilar artery	3.867 (1.325–11.284)	0.013	8.101 (1.942–33.797)	0.004
Proximal basilar artery	2.222 (0.558–8.854)	0.258	2.711 (0.521–14.110)	0.236
Vertebral artery-V4	4.333 (0.902–20.813)	0.067	7.681 (1.311–45.001)	0.024
Mortality				
Age	1.014 (0.915–1.124)	0.787	0.928 (0.815–1.056)	0.256
Initial NIHSS score	1.092 (1.046–1.141)	<0.001	1.121 (1.059–1.186)	<0.001
Recanalization	0.267 (0.092–0.774)	0.015	0.230 (0.064–0.829)	0.025

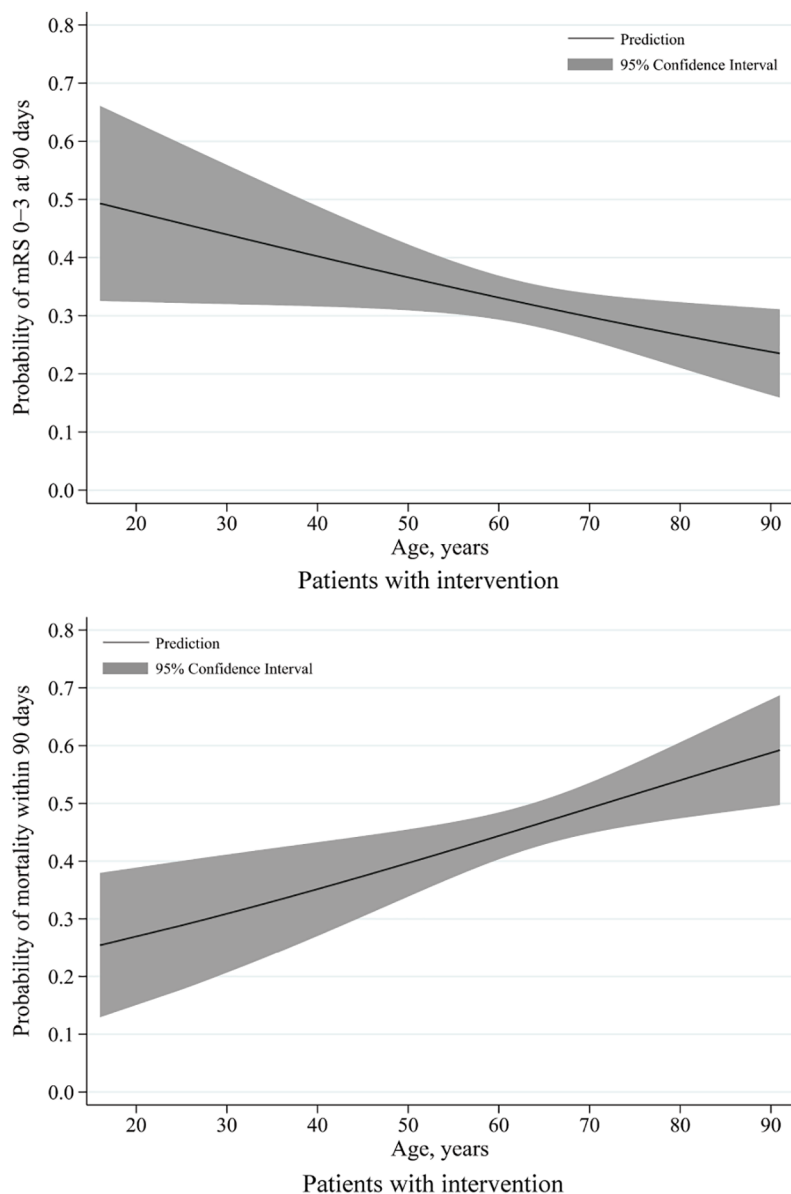
<sup>a</sup>Distal basilar artery was taken as reference.  
CI, confidence interval; NIHSS, National Institutes of Health Stroke Scale; OR, odds ratio.

**Figure 3.** Distribution of modified Rankin scale score at 90 days in patients with intervention.

Shown was the distribution of the modified Rankin scale scores at 90 days in all patients with intervention. The distribution showed that compared with younger patients, the older patients were associated with a higher rate of mortality among all the intervention-treated patients. The overall prognosis following intervention tended to be poor with age.

In the univariate analysis, the elderly patients with intervention showed a higher mortality (54.3% *versus* 44.2%;  $p=0.041$ ; Figure 3) and comparable rates of favorable functional outcome (28.3% *versus* 32.9%;  $p=0.326$ ) and symptomatic intracranial hemorrhage (4.7% *versus* 7.5%;  $p=0.270$ ) compared with those nonelderly. The probability

of favorable functional outcome decreased and that of mortality increased from a young age to the old (Figure 4). An age greater than 75 years remained a predictor of mortality (OR, 1.623; 95% CI, 1.022–2.578;  $p=0.040$ ) when adjusting for dichotomized age, initial NIHSS, PC-CS, hypertension, diabetes mellitus, occlusion site,



**Figure 4.** Predicted probability of clinical outcome by age in patients with intervention.

Of all patients with intervention, the curves showed that decreases in predicted probabilities of favorable functional outcome and increases in predicted probabilities of mortality with age.

The solid line indicates the predicted probability of outcomes and grey shading indicates the 95% confidence interval.

puncture to recanalization time and recanalization on the multivariate analysis (Table 4).

### Discussion

This multicenter study represented the real-world experience of patients 75 years or older with acute BAO treated with intervention using modern

devices and advanced technologies. The major finding of this study was a strong correlation between intervention and favorable outcome among elderly patients with a threefold increase in the likelihood of achieving a 90-day favorable functional outcome and nearly four times as high mortality rate in conservative-treated patients. Along with prior data and case series of BAO, our results provided extensive evidence for further implementation of intervention in the posterior circulation stroke population.

Published literature has reported outcomes following thrombectomy in elderly patients with anterior circulation stroke compared with conservative counterparts. Among the randomized thrombectomy trials of anterior circulation occlusion, the overall outcomes following intervention were significantly more beneficial than with compared with conservative treatment in the elderly subgroups of the ESCAPE trial, DAWN trial (both divided into older *versus* younger than 80 years) and SWIFT-PRIME trial (divided into older *versus* younger than 70 years).<sup>7</sup> Relatively few studies have reported on elderly patients with BAO. Some studies have reported poor outcome rates ranging from 54% to 95% for conservatively treated BAO patients,<sup>2</sup> and have examined the effect of intervention in patients with acute BAO.<sup>15-19</sup> However, few studies have solely focused on elderly stroke population. Our results clearly showed the superiority of intervention with special reference to patients aged 75 years or older. Thus, our study, specifically highlighting the aging population, may throw some light on the treatment of elderly patients with acute BAO.

In our study, there was a higher rate of favorable functional outcome (adjusted OR, 0.262; 95% CI, 0.088-0.788) and decreased mortality (adjusted OR, 0.257; 95% CI, 0.109-0.606) in the interventional cohort than in the conservative cohort. Several of the following observations might contribute to this result. First, the study benefited from the use of widespread, advanced techniques and newer-generation devices, the application of neuroimaging and rigorous patient selection. This led to a high rate of successful recanalization in patients undergone intervention, reaching up to 81.9% in our study. In a series of 214 patients, Bousslama *et al.*<sup>16</sup> demonstrated a strong correlation between recanalization and outcome in patients with vertebrobasilar occlusion stroke treated with intervention with a 10-fold



**Table 4.** Multivariate analysis: predictors of outcome following intervention.

Variables	Functional outcome		Mortality	
	Adjusted OR (95% CI)	<i>p</i> -value	Adjusted OR (95% CI)	<i>p</i> -value
Dichotomized age	1.465 (0.881–2.436)	0.141	1.623 (1.022–2.578)	0.040
Initial NIHSS score	1.102 (1.077–1.127)	<0.001	1.087 (1.063–1.112)	<0.001
PC-CS score	0.834 (0.746–0.934)	0.002	0.887 (0.797–0.986)	0.026
Hypertension	0.674 (0.432–1.052)	0.082	1.183 (0.781–1.790)	0.428
Diabetes mellitus	2.122 (1.274–3.536)	0.004	1.973 (1.270–3.064)	0.002
Occlusion sites				
Distal basilar artery <sup>a</sup>		0.016		0.986
Middle basilar artery	2.257 (1.356–3.757)	0.002	1.009 (0.628–1.620)	0.972
Proximal basilar artery	1.454 (0.795–2.660)	0.224	0.909 (0.514–1.608)	0.744
Vertebral artery-V4	1.791 (0.987–3.251)	0.055	0.991 (0.573–1.713)	0.973
PTR	1.009 (1.005–1.012)	<0.001	1.007 (1.004–1.010)	<0.001
Recanalization	0.194 (0.097–0.386)	<0.001	0.150 (0.088–0.256)	<0.001

<sup>a</sup>Distal basilar artery was taken as reference.  
CI, confidence interval; NIHSS, National Institutes of Health Stroke Scale; OR, odds ratio; PC-CS score, posterior circulation collateral system score; PTR, puncture to recanalization.

increase in the likelihood of achieving good functional outcomes if successful recanalization is attained and twice as high mortality rates in non-recanalized patients. Additionally, the considerate healthcare provided, proper postprocedural care and timely rehabilitation training services also contributed to the functional outcomes.<sup>20</sup>

Second, we observed a higher proportion of embolic rather than atherosclerotic occlusion (51.2% *versus* 44.1%) in the intervention cohort. This was mainly due to the aging population and the increasing prevalence and incidence of atrial fibrillation with age among elderly patients, which were in accordance with the real-world clinical practice in China.<sup>21</sup> Elderly patients with an embolic cause of BAO had a relatively higher rate of good functional outcome than those with an atherosclerotic cause.<sup>19</sup> This is an important point, as the difference in clot morphology and the pathologic mechanism of stroke (i.e. intracranial atherosclerosis) may exert a variable influence on management and outcomes. Of the elderly patients undergone intervention in our study, the rate of favorable functional outcome

was 33.8% among patients with an embolic cause *versus* 21.4% among those with an atherosclerotic cause, but this difference was not statistically significant ( $p=0.130$ ). Mortality was also not significantly different between groups ( $p=0.976$ ). This might be explained by the sampling variability caused by the small number of patients.

Third, the time from onset to treatment, an important prognostic factor for the elderly patients in our study, tended to be shorter than that in patients  $\geq 75$  years of age with symptom onset within 24 h in the BASICS registry.<sup>22</sup> We compared the number and proportion of patients during five time periods stratified by time to treatment between the elderly patients in the BASICS and BASILAR registries: <3 h: 50 (34.7%) *versus* 91 (50.0%); 4–6 h: 50 (34.7%) *versus* 59 (32.4%); 7–9 h: 17 (11.8%) *versus* 16 (8.8%); 10–12 h: 13 (9.0%) *versus* 9 (4.9%); 13–24 h: 14 (9.7%) *versus* 7 (3.8%). And the difference was significant ( $p=0.022$ ). Time to treatment has been widely described as having a major impact on clinical outcome. As indicated previously, a shorter time to treatment was

associated with improved odds for a better clinical outcome.<sup>23,24</sup> Our positive result might result from improvement in emergency triage systems, more timely recognition and earlier administration of medical treatment.<sup>24</sup>

Prior studies of the posterior territories also examined predictors of elderly patients with intervention. Rentzos *et al.*<sup>25</sup> demonstrated in a single series of 110 patients with underwent endovascular stroke treatment in the posterior circulation that a significant association was seen between favorable outcome and younger age ( $p=0.023$ ). Rangaraju *et al.*<sup>26</sup> evaluated 376 of 619 participants in the BASICS registry and showed that age was a predictor for poor outcome. An analysis of 212 BAO patients reported by Kang *et al.*<sup>18</sup> showed that younger age was significantly associated with a favorable shift in the overall distribution of 90-day mRS. In contrast, Mokin and colleagues showed that there were 12 (12%) patients >80 years in the cohort, and only 5 (42%) had an mRS of 0–2 at 3 months *versus* 30 (34%) in patients younger than 80.<sup>15</sup> The authors found that age >80 years was not a predictor for clinical outcome. Bousslama *et al.*<sup>16</sup> also found that age was not associated with good outcome. These results were partially influenced by their one-arm, single-center, study design with a small sample size, the use of earlier-generation retrieval devices and unsophisticated interventionists in some institutions. Only a minority of patients included were of elderly age. Therefore, the results above should be cautiously interpreted. Our study aimed to examine risk factors among intervention-treated patients  $\geq 75$  years to identify predictors of the prognosis of acute BAO. In our multivariate analysis, factors that may influence functional outcome included initial NIHSS score and occlusion site; initial NIHSS and successful recanalization were found to be predictors of mortality in the elderly population. Age, analyzed as a continuous variable, however, showed no correlation with favorable clinical outcome.

The strengths of this study were the comparator arm of the elderly BAO patients who received standard medical therapy alone and the large sample size (up to 182) from a representative database. The use of newer-generation devices and advanced interventional technologies made the results more applicable to current institutions and populations. The study limitations included the observational nature of our BASILAR

registry study, which had the inherent weakness of the nonrandomized clinical trial as exemplified by a selection bias in the treatment of the patients. Among the elderly population with cardioembolic stroke or distal basilar occlusion which were likely to recanalize, the proportion of patients undergone intervention was significantly higher than the proportion of those undergone conservative treatment. This bias can be avoided by developing associated randomized controlled trials. Second, the study was unable to define an upper age limit above which intervention treatment was no longer effective because of the lack of cases. In addition, confounding factors were not fully controlled for between the two cohorts, which may have potentially influenced our results.

### Conclusions

While the elderly population presented with a high overall mortality, we concluded that they were more likely to achieve a favorable outcome after intervention than after conservative treatment. A lower initial NIHSS, occlusion site and successful recanalization were associated with desirable outcomes in elderly patients undergone intervention. For elderly patients with BAO, potential intervention should not be ruled out simply because they are 75 years of age or older.

### Conflict of interest statement

The authors declare that there is no conflict of interest.

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### Supplemental material

Supplemental material for this article is available online.

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